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An ecological and conservation assessment of the fauna of Bombyliidae (Diptera) occurring in the Mkhuze, Phinda and False Bay reserves, KwaZulu-Natal, South Africa

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David Greathead died in October 2006.

ABSTRACT

The savanna is an important biome covering a large area of southern Africa; however its invertebrate fauna are very poorly documented. A variety of invertebrate taxa was sampled within three reserves in this biome, all located in the Maputaland centre of endemism in KwaZulu-Natal, South Africa. Bombyliidae (Diptera) were a significant and easily visible element of the fauna sampled. This paper assesses the fauna of this group, by examining habitat associations and comparing the fauna sampled with data from other regions ('Mfongosi', KwaZulu-Natal; Shimba Hills, coastal Kenya); checklists of species from 'Mfongosi' and Shimba Hills are provided. Species richness for the sampling area was estimated using the survey data, and sampling strategy was evaluated by assessing sampling methods and effort. Twenty two species were sampled during the wet season (November to March), of which 6 are new records for KwaZulu-Natal. These are listed, along with relevant distribution and phenological data. *Bombomyia bicolorata* (Bezzi, 1924) is newly synonymised with *Bombomyia bombiformis* (Bezzi, 1924).

Adult bombyliid species were most strongly associated with broad-leaf vegetational habitats (19 of 22 species). Some 68% of species occurred in *Terminalia sericea* woodland, 41% in *Acacia nigrescens* low open woodland, 32% in *Combretum apiculatum* mountain low thicket, and fewer species in other vegetation types. Active capture using nets along transects was the most effective method used, sampling all 22 species. Species richness estimates for the study region varied from 27 to 33 species, suggesting that 67–73% of the estimated number of species were sampled. Detailed biological studies are required to determine the factors limiting species to particular habitats, particularly adults feeding on flowers and the discovery of the hosts of larval stages.

Most species sampled are widespread with no local endemism, and are therefore not a priority for species-level conservation within the study region. We emphasise their important functional role as pollinators. Many of the species are restricted to the east African coastal vegetation mosaic. Similar systematic sampling of inland localities is urgently required to confirm this biogeographical restriction. Given their widespread distribution patterns, well resolved taxonomy, and ease of sampling, bombyliids may provide an ideal group for studying large-scale biogeographical affinities and patterns across Africa.

KEY WORDS: Diptera, Bombyliidae, checklist, savanna, vegetation types, KwaZulu-Natal, Mkhuze, Phinda, False Bay, habitats, sampling techniques, species richness, biogeography, conservation, new synonymy.

INTRODUCTION

Southern Africa has a particularly rich and varied insect fauna, with 26 orders, 569 families, and approximately 7753 genera (Scholtz & Chown 1995). This fauna includes an estimated 60 000 described species; given an average level of endemicity of 70%, this would represent about 42 000 endemic species (Le Roux 2002). The Savanna biome is the largest in southern Africa, occupying 46% of its area, and over one-third the area of South Africa (Low & Rebelo 1998). The biome is therefore an obvious area of focus for conservation planning in South Africa, although to date it has received minimal attention from invertebrate researchers.

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Many entities of biodiversity, particularly at species level, have not yet been discovered, let alone have their distributions been mapped at a spatial scale appropriate for regional conservation planning (Ferrier *et al.* 2002). Furthermore, data on the threatened status of insects and other invertebrates are almost non-existent (Stork 1997). Extensive studies of biodiversity, endemism, rarity, congruence and surrogacy do not exist for invertebrate communities in the Savanna biome. These data sets are essential for the development of decision-making tools to facilitate effective conservation planning (Howard *et al.* 1998; Wessels *et al.* 1999; Cowling & Heijnis 2001; Lombard *et al.* 2003; Oliver *et al.* 2004). Therefore, there is an urgent need to characterise invertebrate biodiversity in this biome.

This study of the invertebrate fauna of Mkhuze Game Reserve, Phinda Private Game Reserve and False Bay Park (all in north-eastern KwaZulu-Natal) sampled a suite of taxonomic groups which can be described as a multi-taxa or 'shopping basket' approach (Oliver & Beattie 1996). The following groups were sampled using a variety of methods: Lepidoptera (butterflies), Hymenoptera (Apoidea), Diptera, Neuroptera, Odonata, Hemiptera (Cicadellidae), Coleoptera (Cetoniinae, Scarabaeinae), Orthoptera, Blattodea, Araneae (Thomisidae, Oxyopidae, Araneidae), Isoptera, Scorpionida, Mollusca, Myriapoda (Diplopoda, Chilopoda) and Oligochaeta. The aim of this study was to develop an understanding of invertebrate biodiversity in a savanna ecosystem. The main objectives were to: (1) provide crucial baseline data for key invertebrate groups; (2) highlight the significance and conservation value of invertebrates; (3) assess species turnover; (4) investigate the effects of biotic and abiotic factors on invertebrate community structure patterns; and (5) test assumptions used in conservation planning.

The Bombyliidae are a significant and easily visible element in the fauna of the reserves studied and have a relatively well resolved taxonomy, and are thus a suitable focus taxon in the Diptera for ecological, biogeographical and conservation studies. Most species are readily identifiable to family, even by non-specialists. The family is one of the dominant families of Diptera in the afrotropics, with 98 genera and 1439 species known (Evenhuis & Greathead 1999, 2003). Greathead and Evenhuis (2001) reviewed our knowledge of the Afrotropical Bombylioidea (Mythicomyiidae and Bombyliidae) and provided keys to genera and references to other keys for the identification of species. Knowledge of the fauna varies from region to region but the southern African fauna is relatively well known following the major revisionary studies of A.J. Hesse (e.g. 1938, 1956). In terms of sampling bombyliids in the reserves, our specific objectives were to: (1) provide a checklist of genera and species occurring in the region; (2) identify the best sampling method; (3) estimate the species richness of the region, and the sampling effort required to adequately sample the fauna; (4) describe species habitat affinities and phenology; and (5) draw biogeographical and conservation conclusions.

Adult Bombyliidae are most active in bright sunshine and tend to settle when the sky is heavily overcast. Many members of the Bombyliinae, such as *Bombomyia* Greathead and *Systoechus* Loew, are strong and agile fliers, and males are territorial, hovering over a marker and then darting toward any insects passing nearby to investigate them, either as potential mates or as rivals. Adult Anthracinae and Lomatiinae fly close to the ground and are often found basking on patches of bare earth. Many have disruptive colour patterns which break up the outline of the settled insect. Colour patterns in these subfamilies and some genera of Bombyliinae (notably *Bombylella* Greathead and *Bombylisoma* Rondani) may also be sexually dimorphic, with males exhibiting patches of brightly coloured or metallic scales which appear to be used in courting females (DG, unpubl. observ.).

Adults of most genera have fully developed mouthparts adapted for feeding on flowers (e.g. Szucsich & Krenn 2002). Both sexes feed on nectar but females also feed on pollen and many have specialised hairs on the fore tarsi for gathering pollen (Neff *et al.* 2003). There are few studies on the role of Bombyliidae as pollinators, but most species are probably generalists—refer for example to the studies in Namaqualand (Northern Cape, South Africa) by Struck (1992, 1994).

All reared species are parasitoids or predators, almost exclusively of larvae or pupae of other insects (Yeates & Greathead 1997). Some, for example Toxophorinae, lay macrotype eggs on or near the host, but most—notably the large speciose subfamilies Bombylliinae and Anthracinae—lay large numbers of small eggs which are coated in sand particles before being ejected into irregularities in the soil surface. These species have a specialised 'sand chamber' formed by the terminal abdominal segments of the female (Mühlenberg 1971). Their oviposition behaviour involving the collection of sand particles accounts for the greater diversity of the sand chamber Bombyliidae in arid and semi-arid areas where patches of bare soil can be found.

Of the species listed in the checklist (Appendix 1), only *Spogostylum incisurale* (Macquart) has been reared—as an ectoparasitoid of the larvae and pupae of *Loxostege frustalis* Zeller (Lepidoptera: Pyralidae) and its hymenopterous parasitoids in South Africa (Möhr 1990). Known hosts of Exoprosopini are principally cocoons of soil-breeding wasps, but *Micomitra* Bowden species are known as parasitoids of pupae of Myrmeleontidae. *Systoechus* species are well known as predators in the egg-pods of Acrididae, and *Bombylella* species have been reared from the dung balls of Scarabaeidae (Yeates & Greathead 1997 & references therein).

MATERIALS AND METHODS

Study site

Fieldwork was carried out in Mkhuze Game Reserve (27.67°S:32.27°E), Phinda Private Game Reserve (27.78°S:32.35°E) and False Bay Park (27.94°S:32.38°E) (Fig. 1). Phinda Private Game Reserve covers 14 000 ha, Mkhuze 40 000 ha, and False Bay Park 2 500 ha. The reserves are situated in the diverse region known as the Maputaland Centre, which consists of a mosaic of mainly extensive savanna communities arranged in complex patterns; the Centre also contains forest, grassland and swamps, largely determined by local edaphic conditions (Van Wyk 1996). The Maputaland Centre, for its size, is one of the most remarkable areas of biodiversity in the world, with a high number of endemics representing virtually the whole taxonomic spectrum (Van Wyk 1996).

Sites were chosen from vegetation data and geology maps to represent a range of vegetation and soil types (Fig. 1). Sampling was conducted over three years during the summer months (November to March) between 2002 and 2005. Sampling sites were 1 ha plots of uniform vegetation types. Forty three different sites were sampled between November 2002 and March 2005; 20 sites were re-sampled at different times during the summer seasons.

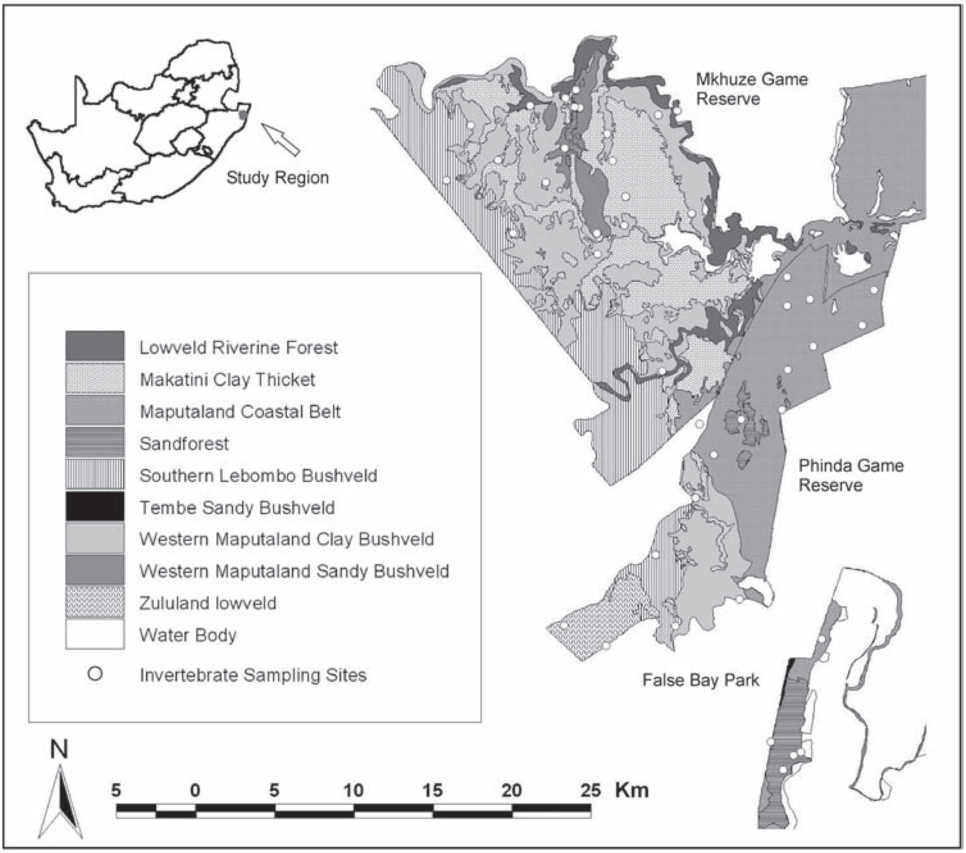

Fig. 1. Study region located in north-eastern KwaZulu-Natal, South Africa, showing the vegetation types of the reserves identified by Muchina and Rutherford (2005). Forty-three 1 ha invertebrate sites were sampled (indicated by white dots) for one day, using a variety of methods; 20 of these sites were re-sampled in different months and years.

Sampling, sample processing and species identification

Fieldwork was carried out by teams of Earthwatch volunteers, with each team supervised by a research scientist. Volunteers received training prior to the fieldwork. One site was sampled each day, and active sampling was completed by teams between 07h00 and 13h00.

Only representative invertebrate samples were kept for identification in order to minimise the effect of sampling on invertebrate populations; however the abundance of each invertebrate species was recorded. When possible, replicate invertebrates were released at the collection site after being recorded. Specimens retained were frozen or placed in killing jars containing ethyl acetate, and then preserved in 70% ethanol, or pinned. They were sorted into broad groups and recorded at the field station, then sorted to a lower taxonomic level in the laboratory. Species identification was carried out by expert taxonomists.

Field techniques

Bombyliids were sampled at each site using transect walks, colour pan traps, baited traps and sweep netting.

Special mention should be made of Malaise traps. These were not used as they need to be set for extended periods. Given the movement of large game in the study region, this was not possible. We do not consider that Malaise samples would have provided better quantitative estimates; they would just have sampled a subset of the species present.

Fifty metre transect walks were performed in different areas of the sampling site. A 50 m tape was laid out in a straight line at a location which was representative of the vegetation type and which covered a variety of micro-habitats. Each transect walk was carried out by three people observing five metres either side of the transect line.

Colour pan traps were set for a period of 24 hours. Blue and yellow pan traps with a diameter of 22 cm, an internal diameter of 20 cm, and a depth of 2 cm, were set in two lines 10 m apart, with each pan trap set at a 10 m interval. The pan traps were filled with approximately 150 ml of a water, detergent and glycerol mix, to ensure a low surface tension and to reduce evaporation.

Baited traps with a uniform diameter of 30 cm, length of 110 cm and mesh size of 1 mm, suspended at least 1 m from the ground, were set for 24 hours at each sampling site. Fermented fruit bait was placed on the solid base of the trap. The baited traps were set in two parallel lines approximately 20 m apart, with each trap set a minimum of 10 m apart, although the location of suitable trees was often the deciding factor in terms of actual trap placement.

Two sets of low-level vegetation were sampled by sweeping, using 35 cm diameter nets (1 mm mesh), and the contents of 10 full sweeps comprised one sample.

A non-quantifiable technique of unspecified collection was also used at six of the sites, i.e. the random collection of species, referred to as general collecting. Specimens sampled in this way were included in the estimates of species richness but were not used when assessing sampling techniques or effort.

Sampling effort

During the survey, sampling effort varied to enable questions associated with sampling efficiency to be tested. During the first two sampling seasons two 50 m transects were sampled, but in the third sampling season four 50 m transects were sampled at each sampling plot. The number of pan traps set varied across the seasons. In seasons one and two, five blue and five yellow pan traps were set, but in the third season ten blue and ten yellow traps were set. During the first season, due to logistical constraints (n = 7 sites), pan and baited traps were not set at sites sampled in Phinda Private Game Reserve.

ANALYSIS

Habitat assessment

Two vegetation classifications derived from vegetation and land cover surveys were used for a qualitative analysis of Bombyliidae species and habitat type. Sampling was carried out across reserves at locations where detailed vegetation surveys and soil analysis had previously been done (Repton 2006). Repton's study provided a local scale classification. The second approach analysed in this paper is the new SANBI national regional-level classification (Muchina & Rutherfold 2005).

Phenology

A study of the species sampled in each month was carried out to assess temporal variation across the summer months. The number of unique species—defined as species that were only sampled in the month in question—were recorded. All available data was used for this assessment. Unique species were assessed to determine the optimal sampling period needed to assess species diversity.

Estimates of species richness

EstimateS version 7.5 (Colwell 2005) was used to plot the species accumulation against the number of individuals sampled. A two-parameter hyperbola regression curve (Michaelis-Menten equation) was fitted to estimate the species richness of the study area (Colwell & Coddington 1994; Magurran 2004; Colwell 2005). For comparative purposes Chao 2 richness estimators, incidence-based coverage estimator (ICE) and the second order Jackknife species richness estimator were calculated using EstimateS. These were selected as they have been shown to be good estimators with the least bias (Chazdon *et al.* 1998; Gotelli & Colwell 2001; Longino *et al.* 2002; Ugland *et al.* 2003; Chao 2005).

Optimal number of sites

Two series of estimates were calculated to establish the optimal number of sites which would be required to assess different percentages of the estimated number of Bombyliidae species in the region. The first series used data from the 43 different sites sampled (two transects and two sweep samples); the second, data from 19 sites (four transects and two sweep samples). The Michaelis-Menten equation was used to extrapolate the sampling based species accumulation curve to provide an estimate for the number of sampling sites required. We are aware of the potential error in the extrapolation of datasets and that the prediction of the number of species by extrapolation is done under the condition that all properties remain the same as defined in the original data.

RESULTS

Some 145 specimens representing 22 species in 12 genera were collected over the three sampling seasons. The vegetation classification used is that of Repton (2006). Note that the classification 'savanna' is used at sites where there is no formal vegetation classification. As Repton's classification was published after the field portion of the study had been completed, the classification on the actual insect labels may differ. The terms 'woodland', 'savanna', 'thicket' and 'steppe' were used to indicate degree of tree cover in what otherwise is represented as the 'savanna biome' in maps.

Checklist

A comprehensive checklist of all species collected in the study area is presented in Appendix 1. It includes information on distribution, biology, habitat, phenology and collection techniques.

TABLE 1

Bombyliidae species and associated vegetation type (Repton 2006). Abbreviations: n – the number of sites sampled in the vegetation type, A – *Acacia grandicornuta* short open woodland, B – *A. luederitzii* low thicket, C – *A. nigrescens* low open woodland, D – *A. nilotica* and *A. karoo* low open woodland, E – *A. nilotica* and *A. tortilis* open woodland, F – *A. xanthophloea* forest, G – *Combretum apiculatum* mountain low thicket, H – *Spirostachys* woodland low closed woodland, I – *Terminalia sericea* low open woodland, J – sand forest, K – fig (*Ficus sycomorus*) forest. Figures in parentheses denote that the species was recorded as a result of additional sampling effort from increased sampling intensity (e.g. increase from 2 to 4 transects) or sites which were repeated at different temporal intervals. Specialisation refers to whether the species was only found in broad leaf (B), *Acacia* (A), or *Acacia* and broad leaf mix (M).

Subfamily	Tribe	Genus	Species	Specialisation	***Acacia***						**Broad leaf**				
					A (n=4)	**B** (n=3)	**C** (n=3)	**D** (n=3)	**E** (n=2)	**F** (n=3)	**G** (n=2)	**H** (n=3)	**I** (n=9)	**J** (n=7)	**K** (n=1)
Anthracinae	Anthracini	*Spogostylum*	*transiens*	M	1		1				(1)		(1)		
	Exoprosopini	*Exoprosopa*	*apiformis*	M		1	(1)						1		
			dimidiata	B									2 (1)		
			elongata	B							(1)				
			major	B									1		
			metopargyra	M				1			1				
			morosa	M		1							1		
			punctulata	A		1									
		Heteralonia	*corvina*	A	(1)	1									
		Litorhina	*nyasae*	B									(1)		
			obumbrata	A			1								
		Micomitra	*perlucida*	B									(1)		
	Villini	*Exhyalanthrax*	*transiens*	M		2 (1)	1		1				2 (1)	(1)	
Bombyliinae	Bombyliini	*Bombomyia*	*bombiformis*	M			1				(1)				
			discoidea	B									(1)		
		Bombylella	*delicata*	M	(1)								2	(1)	
		Bombylisoma	*coracinum*	B									(1)		
		Eurycarenus	*sessilis*	B									(1)		
		Systoechus	*bombycinus*	M	(1)		2 (1)	2		(2)	(1)		2	1	
			chrystallinus	M			(1)							(1)	
			silvaticus	M	2 (1)	1	3 (2)	2		2 (1)	(1)		2 (1)		
Lomatiinae	Lomatiini	*Notolomatia*	*heterocoma*	M			(1)				1	1	(3)		
Species richness					5 (3)	6	9 (3)	3	1	2 (1)	7 (5)	1	15 (7)	4 (3)	0

Habitat affinities

Within the reserves, Bombyliidae were captured in all the sampled vegetation types, except fig forest (Table 1). Fig forest was not a focus of this study, and as such only one site was sampled in that habitat. The broadest manner of separating the habitat types based on woody vegetation composition is into broad-leaf habitats (dominated by broad-leafed species) versus *Acacia* habitats (dominated by thin-leafed *Acacia* species). Eight species were restricted to broad-leaf habitats, three were restricted to *Acacia* habitats, and 11 species occurred across both types. Adult bombyliids therefore are likely to be strongly associated with broad-leaf habitats (19 of 22 species).

Fifteen species (68%) occurred in *Terminalia sericea* woodland, 41% in *Acacia nigrescens* low open woodland, and 32% in *Combretum apiculatum* mountain low thicket. The balance of the habitats contained 55% of the species captured in the study. Ten species were captured only in one habitat type, and seven of those occurred in *T. sericea* woodland, with one each in *Acacia luederitzii* low thicket, *A. nigrescens* low open woodland, and *C. apiculatum* mountain low thicket.

In terms of vegetation type, the most species (14) were recorded from *T. sericea* low open woodland, whilst the fewest were recorded from *Acacia xanthophloea* forest and *Spirostachys* woodland (2 species each).

In terms of soil substrate, *T. sericea* woodland and sand forest are on very loose, sandy soils. The balance of the habitats have varying degrees of clay, with the *Acacia* habitats having the highest clay content. Bombyliidae with a sand chamber (all of those sampled) require patches of bare friable soil to fill the sand chamber prior to oviposition, and so are uncommon in dense vegetation or in habitats with heavy clay soils that do not crumble when dry. Most species pupate in soil and the pupae are killed by waterlogging (DG, unpubl. observ.), so that Bombyliidae are rare in areas prone to seasonal flooding of several weeks or more. Interestingly, the species sampled, although most abundant in *T. sericea* woodland—as would be expected (14 species)—are poorly represented in sand forest (only three species), but relatively abundant in three of the four *Acacia* vegetation types (5 to 8 species).

In terms of the sampling, bombyliid species are generally habitat specialists, with ten species occurring only in one habitat type (species of *Exoprosopa* (4), *Lirorhina* (2), *Micomitra* (1), *Bombomyia* (1), *Bombylisoma* (1), *Eurycarenus* (1)) and four species in only two habitat types. Of the four species occurring in two habitat types, three of these occurred in both an *Acacia* and a broad-leaf habitat type, suggesting that the specialisation of these species is probably not related to woody vegetation community characteristics. By contrast, *Systoechus bombycinus* Hesse, 1938 and *S. silvaticus* Hesse, 1938 are habitat generalists, occurring across 70% of the habitat types. Unfortunately our knowledge of bombyliid hosts is very limited and it is therefore difficult to conclude whether habitat specialisation (as in four *Exoprosopa* species) is determined by host biology/distribution. There is an urgent need to accumulate more life history information so that questions such as these can be answered.

Muchina & Rutherford's (2005) vegetation classification showed that: Western Maputaland sand bushveld (n = 4 sites) recorded 14 species, Western Maputaland clay bushveld (n=9) 11 species, Southern Lebombo bushveld (n=4) nine species, Maputaland coastal belt (n=13) four species, Makatini clay thicket (n=3) four species, sand forest (n=4) three species, Zululand lowveld (n=2) two species, lowveld riverine forest (n=3) one species and Tembe sandy bushveld (n=1) one species.

Seven species were only sampled in Maputaland sand bushveld, two species were only sampled in Southern Lebombo bushveld and one species was unique to Western Maputaland clay bushveld.

Phenology

This study sampled across the summer months of November, January and March. Twelve of the species (52%) were found in one month only, 8 (35%) were found in two months, and only three species were found across the whole summer (Fig. 2).

Species richness

We did not sample the fauna of the region completely (Fig. 3). Extrapolaton of species accumulation curves indicates that between 27 and 33 species exist in the region. Using the regression equation (R^2=0.99) the species accumulation curve asymptotes at 31.70 species (32 species) (Fig. 3). The second-order Jackknife estimator calculates a species richness of 32.88 (33 species), Chao 1 estimates 27.25 (27 species) and ICE estimates 29.71 (30 species). We therefore sampled between 67 to 73% of the estimated number of species.

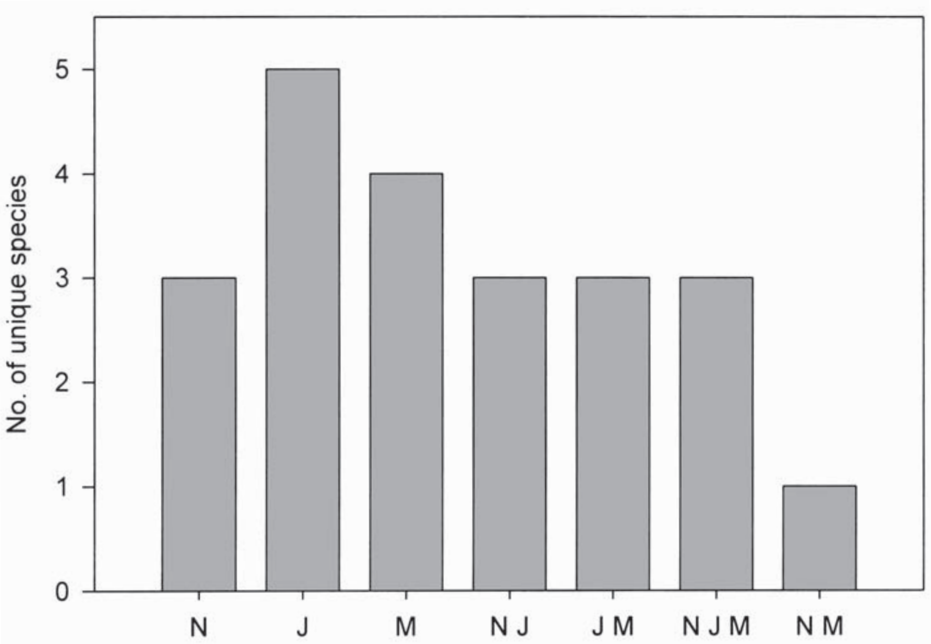

Fig. 2. Phenology of bombyliid activity. Each bar represents the number of unique species sampled in the months identified: November (N), January (J) and March (M). A unique species is a species only sampled in that month or combination of months. No sampling was undertaken in December or February.

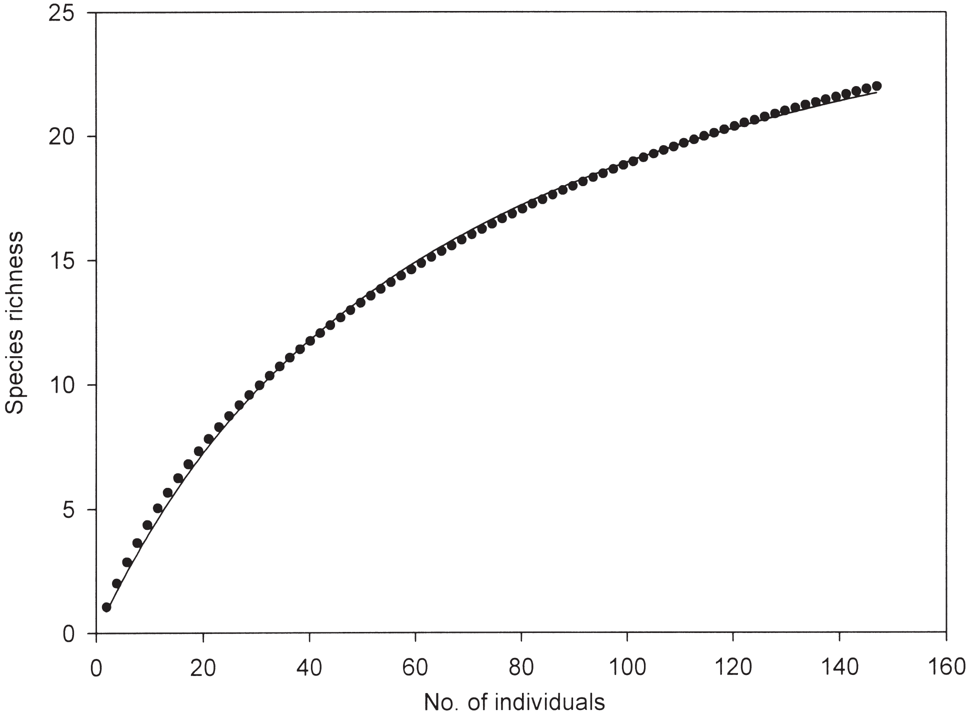

Fig. 3 Individual based species accumulation curve for the Mkhuze and Phinda game reserves and False Bay Park based on all Bombyliidae species sampled during the survey. The Michaelis-Menten equation predicts an asymptote at 31.7 species (R^2=0.99).

Sampling methods

All 22 bombyliid species were collected in the transects. Pan traps captured only four species, and sweep-netting grass yielded three species. Therefore, the transect data were used to provide estimates for the optimal number of sites required to effectively sample Bombyliidae species. Species accumulation curves were based on (1) two transects and (2) four transects per site. The use of four transects increases the sampling efficiency (Fig. 4), with the estimated species richness of 28.5 from two transects and 34.3 from four. Note

TABLE 2

Number of sites required to sample the bombyliid fauna. Extrapolation of Michaelis-Menten equation fitted to the two species accumulation curves shown in Fig. 4. The equation was solved to estimate the number of sites required to sample different percentages of estimated species richness.

% of estimated	Estimated no. of required sampling sites	
species richness	2 transects	4 transects
50	40	29
75	118	83
80	158	110
85	222	156
90	356	248
95	751	527

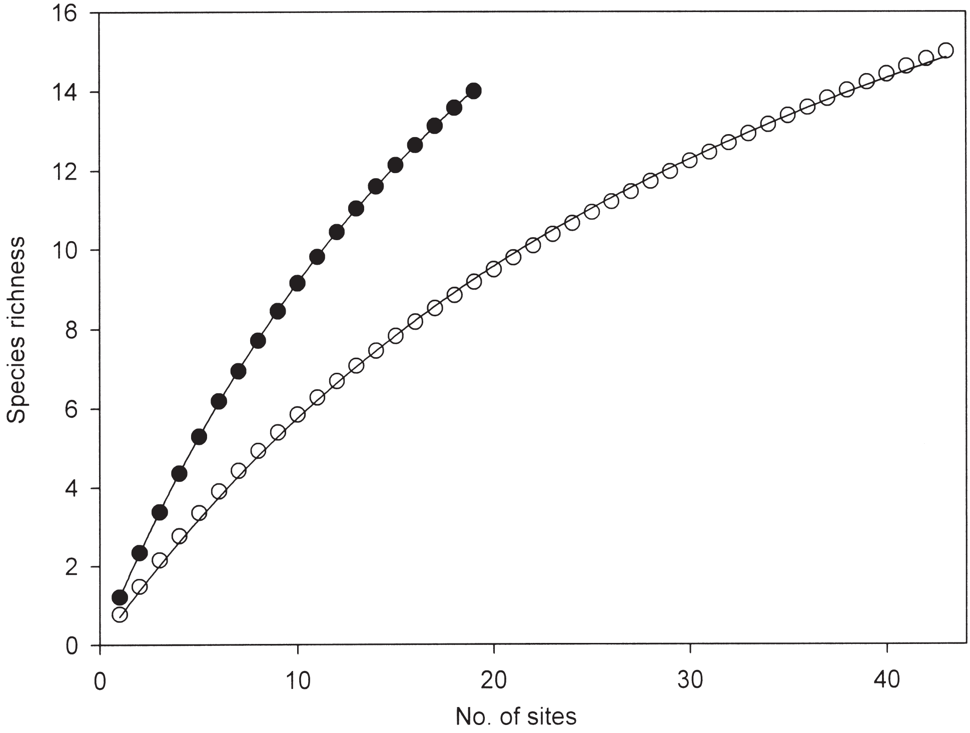

Fig. 4. Number of sites required to sample the bombyliid fauna. Sampling based species accumulation curves for (1) minimum sampling effort at each site based on 2 transects (○), and (2) maximum sampling effort based on 4 transects (●). The Michaelis-Menten equation was fitted to extrapolate and to estimate the optimal number of sampling sites required (Table 2). R^2=0.99 for each curve.

that these estimates are based on a reduced data set, and the individual based estimates described above provide a statistically more powerful estimate. Extrapolation of the Michaelis-Menten equation (Table 2) indicates that a large number of additional sites would be required to sample the missing species. Based on our sampling strategy it is unlikely that the additional 25% of the species would be sampled, as logistically it would not be viable to increase the number of sites beyond those used. Additional effort could include other methods such as the use of Malaise traps, sampling in specialised habitats that were missed, or sampling at different times of the year, such as the dry winter.

DISCUSSION

All of the species recorded were previously known from localities with tropical African woodland and savanna, although seven have not previously been found in KwaZulu-Natal (see Appendix 1). Some of the species occupy a range of habitats from semi-arid steppe to savanna woodland, but the majority are confined to localities on the east African coast and adjoining lowlands, where they are found in areas with savanna and woodland with perennial grass cover.

This zone is designated 'forest savanna mosaic' or 'East African coastal mosaic' (White 1983) on vegetation maps and is taxonomically distinct from structurally similar vegetation in West Africa. It extends more or less continuously from near the estuary of the Juba River in Somalia (1°N) south to the Alexandria Forest north-east of Port Elizabeth (34°S). The sector south of the mouth of the Limpopo River (25°S) is described as the 'Tongaland–Pondoland regional mosaic' (White 1983). Much of the natural vegetation of the zone is now replaced by cultivation, but some relatively natural areas remain, including the Mkhuze Game Reserve, Phinda Private Game Reserve and False Bay Park. These lie in the southern part of the Maputaland Centre which extends north from the St Lucia Estuary to the mouth of the Limpopo River (Van Wyk 1996). It seems likely that the entire zone has long comprised a mosaic of vegetation types including forest, woodland, thicket and grassland as a result of burning, grazing by game, variations in soil type and the availability of ground water. This vegetation mosaic remains a feature of the Maputaland Centre.

In order to evaluate the bombyliid faunal diversity sampled in the present study, comparable samples from other localities are needed for comparison. However, in the absence of similar systematic sampling elsewhere, a well collected area with comparable vegetation and fauna would provide a sample which enables a broad evaluation of diversity and geographical distribution of the species sampled. Between 1962 and 1982 collections of Bombyliidae were made periodically by D.J. Greathead, and latterly also by R.H. Markham whilst studying tsetse fly parasitoids in the Shimba Hills National Reserve, Kenya (Markham 1986). The reserve occupies 192 km^2 at 120–450 m above sea level, and comprises a mosaic of forest, savanna and grassland, straddling the coastal hills south-west of Kwale Forest Station (4°12'S:39°27'E). Some 34 species in 12 genera were collected (Appendix 3). These include three species and six genera in common with the present study area. If species collected at other Kenyan coastal localities are also considered, another species and a further genus would be shared with the KwaZulu-Natal reserves. The only comparable sample from KwaZulu-Natal is the Bombyliidae collected at Mfongosi by W.E. Jones during 1911–1934 (although Jones was based near Kranskop in the Tugela Valley, it appears that his insect collecting may have ranged eastwards towards coastal areas). Records of species in his collections in the South African Museum are to be found in Bezzi (1921) and Hesse (1938, 1956), totalling 30 species in 16 genera (Appendix 2). Four of these species and nine of these genera are also present in the study area. However, Appendix 2 also includes species collected at other coastal hinterland localities. These include a further eight species and one genus recorded in the study area. Thus overall, 12 species and 10 genera found in the study area have also been collected at other localities on or adjacent to the northern KwaZulu-Natal coastal hinterland.

The known bombyliid fauna of the northern KwaZulu-Natal coast area comprises 58 species, and that of the Kenya coast, 39 species. However, if species occurring on the coast in one of these areas and inland in the other but likely to occur on the coast are included, these totals become 64 and 50 species with 28 common to both. Thus, some tentative conclusions can be drawn about the Bombyliidae sampled in the study based on comparisons with the Mfongosi and Shimba Hills lists, and the wider comparison with the overall species register for the northern KwaZulu-Natal coast area and coastal Kenya; it should be borne in mind that seven species now found in the study area had not previously been recorded from KwaZulu-Natal.

The species accumulation curve (Fig. 3) indicates a likely total number of species present in the study area at 32, however the number of species sampled was 22. This is less than the totals for Mfongosi and Shimba Hills. Possible reasons are:

(1) Phenology. Sampling in the study area was only carried out during the rainy season from November to March. During this period species attacking hosts such as solitary bees and non-diapausing grasshopper egg-pods are active at the beginning, and towards the end. Species attacking pupae of Lepidoptera, cocoons of wasps and grasshopper egg-pods of species that diapause during the dry season begin to be active and continue to be so during the early part of the dry season. Some of these late season species were probably missed.

(2) Sampling methods. Experience elsewhere, e.g. Namibia (Greathead 2000*a*, *b*, 2005, 2006) shows that the larger robust species that are active fliers such as larger Bombyliinae and Anthracinae, predominate in netted collections but are rare or absent from baited and pan traps. On the other hand, smaller and less robust species are rare in netted collections but frequent in traps. Malaise traps could have increased the number of these, but were not used in the present study.

Keeping the above in mind, the composition of the Bombyliidae from Mkhuze, Phinda and False Bay can be reviewed in relation to the fauna of 'Mfongosi' and Shimba Hills. It is immediately apparent that there are no representatives of the Toxophorinae which are mainly active during the dry season at the other sites. Thus, it may be expected that at least one species each of the genera *Geron* Meigen and *Toxophora* Meigen should occur in the study area. *Geron* species parasitise larvae and pupae of Lepidoptera which develop in concealed habitats (stem borers, leaf rollers, bagworms). *Toxophora* species are principally parasitoids in nests of eumenid wasps.

The expected genera of Bombyliinae are present but further species of each may be present, particularly species of *Systoechus* attacking diapausing egg-pods. Widespread species of *Bombylella*, such as *B. elegans* (Wiedemann), *B. kilimandjarica* (Speiser) and *B. rufiventris* (Macquart) are also likely to be found as are further species of *Bombylisoma* which occupy similar vegetation types. *Hyperusia* Bezzi may also be found eventually in the dry season. Other species of *Notolomatia*, notably the common southeast African *N. pictipennis* (Wiedemann, 1828), is also a possibility.

In the Anthracinae it is notable that no *Anthrax* species were captured. However, African *Anthrax* species are noted as parasitic in mud wasp nests attached to earth banks, rock faces or buildings and would not be likely to be found on the transects although they might have been encountered during general collecting near buildings or with use of Malaise traps. Other species of *Exhyalanthrax* Becker parasitising puparia of Diptera are likely to be active in the dry season, e.g. *E. abruptus* (Loew) and *E. lugens* (Loew), both studied in the Hluhluwe and Umfolozi reserves before tsetse eradication (Fiedler & Kluge 1954), but their hosts are not limited to tsetse flies. Finally, no species of *Petrorossia* Bezzi, which are most frequent in the dry season, has been found. *P. fulvipes* (Loew), a species of woodland vegetation, and *P. tropicalis* Bezzi, found in more open savanna or grassland, are both widespread and common species.

None of the species found in the study area and those mentioned as likely to occur there are restricted to the Maputaland Centre. However, many of them are restricted to, or largely restricted to, the 'East African coastal mosaic' zone. Likewise those other species listed in Appendix 2 from KwaZulu-Natal are not endemic to it, with the exception of *Systropus zuluensis* Hesse known only from four males collected at Mfongosi (Hesse 1938). *Systropus* species are mimics of Hymenoptera, chiefly

Ichneumonoidea and Sphecidae, and their larvae are parasitic on the larvae and pupae of Limacodidae. Since they place their eggs on the host, they do not require bare soil, and *Systropus* is therefore one of the few genera of Bombyliidae that is more abundant in densely vegetated localities (forest and woodland).

Much of the East African coastal mosaic zone is densely populated and heavily cultivated outside forest and game reserves. Thus these reserves merit preservation from agricultural or tourist development which has occurred along much of the KwaZulu-Natal coast and elsewhere, notably the Kenya and northern Tanzanian coasts.

In conclusion, there are several results providing insight into the conservation value of bombyliids:

(1) Bombyliids are an easily visible component of the fauna, are common, and probably make a strong contribution to the function of pollination. Twenty two species, collectively spread across most habitats, implies that they will be pollinating a range of species, and as such would be an important component of the generalist pollinator guild (refer for example to the papers of Struck (1992, 1994), although information is limited).

(2) Although the diversity of bombyliids is relatively high (22 species from a single family), and they perform an important ecological function (pollination), they are probably not good indicators of either diversity or ecological function. The reason for this is that they are not easily captured in large numbers at particular localities, which means that the probability of accurate density estimates at such localities is unlikely.

(3) The bombyliid species studied are not a priority for conservation at a particular location. This is because they are widespread species, with no local endemism (as opposed for example to millipedes, where a large proportion of species at any particular location are endemic to that location (Hamer & Slotow 2002)). Because of their widespread distribution, a single reserve such as Mkhuze should serve to conserve most species, and only a few species would occur only in the gaps between widely separated reserves. However, individual reserves which protect natural habitats representative of the vegetation types occurring in the broader region will serve to conserve the highest number of species. The presence of a number of such reserves in southeast and eastern Africa is nevertheless the ideal scenario for conservation of the bombyliid fauna.

(4) Extensive collecting in southern Africa for over a century and recent intensive collecting in Namibia have provided evidence that some species are restricted to the eastern coastal lowlands and others to more arid environments. The results of this study support this conclusion and the concept of a distinct Eastern African coastal biogeographical zone. However, adequate sampling has not taken place inland (e.g. on the central plateau of southern Africa), and is urgently required to confirm this biogeographical pattern. Given their widespread distribution patterns, bombyliids may provide an ideal group for studying large-scale biogeographical affinities and patterns across Africa, and further attention should be paid to this objective.

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APPENDIX 1

Species checklist of Bombyliidae sampled in the Mkhuze, Phinda, False Bay reserves in north-eastern KwaZulu-Natal. Asterisk indicates a new record for KwaZulu-Natal (KZN). The taxonomic opinions expressed in this list are those of the senior author. All specimens are deposited in the Diptera collection of the Natal Museum, Pietermaritzburg.

Bombyliinae

Bombyliini

Bombomyia Greathead, 1995

Distribution: Afrotropical, southern Palaearctic, Oriental.
Biology: Nothing known of hosts. Large, robust, strikingly coloured species mimicking large hairy bees such as *Xylocopa* spp. Males hover over a marker to attract females.

Bombomyia bombiformis (Bezzi, 1924)

Bombomyia bicolorata (Bezzi, 1924), **syn. n.**
Distribution: Malawi, South Africa (KZN*, Mpumalanga), Tanzania, Zambia, Zimbabwe.
Habitat: Savanna, woodland and thicket.
Mkhuze: *Acacia nigrescens* low open woodland, *Combretum apiculatum* mountain low thicket.
Phenology: March.
Method: Transect, pan trap.
Comments: These specimens resemble *B. bicolorata*, otherwise known only from a single male and a single female from Malawi, caught at the same time as a female of *B. bombiformis.* Both Bezzi (1924) and Paramonov (1955) commented on the close similarity of the two species and suggested that *B. bicolorata* could be a colour variety. Having examined more specimens of *B. bombiformis*, we conclude that this suggestion is correct and that *B. bicolorata* is a synonym of *B. bombiformis* which, like the closely related *B. discoidea*, is variable in details of the colour pattern.

Bombomyia discoidea (Fabricius, 1794)
Distribution: African savannas, southern Palaearctic Region.
Habitat: Savanna and steppe.
Mkhuze: *Terminalia sericea* low open woodland.
Phenology: February.
Method: Transect.
Comments: One of the most widespread Old World species. Colour pattern very variable.

Bombylella Greathead, 1995

Distribution: Mainly Afrotropical, also southern Palaearctic and Oriental.
Biology: *B. ornata* (Wiedemann, 1828) and *Bombylella* sp. reared once each from dung balls of Scarabaeidae. Less than 10 mm, delicate species, those from Africa with mainly black vestiture ornamented with tufts of bright coloured hair or opalescent or metallic coloured scales. The ornamentation is probably for species recognition in dense vegetation (open forest, woodland).

Bombylella delicata (Wiedemann, 1830)
Distribution: Southern and eastern Africa, south-western Arabia.
Habitat: Savanna and steppe.
Mkhuze: *T. sericea* low open woodland, *Acacia grandicornuta* short open woodland, sand forest.
Phinda: *T. sericea* low open woodland.
Phenology: November, January, March.
Method: Transect.

Bombylisoma Rondani, 1856

Distribution: Afrotropical and Palaearctic, also Oriental.
Biology: Not reared. Similar to *Bombylella* in appearance. There are two species groups in Africa: *B. senegalense* group are dull brown, black or yellowish with silvery scales on frons only and are found in open savanna and steppe; *B. argyropugum/nucale* group are black with bright hair and/or scales like *Bombylella* spp. and are found in woodland and forest.

Bombylisoma coracinum (Loew, 1863)
Distribution: South Africa (Free State, KZN*, 'Transvaal'), southern Tanzania.
Hosts: Not reared.
Habitat: Savanna.
Mkhuze: *T. sericea* low open woodland.
Phenology: November.
Method: Transect.

Eurycarenus Loew, 1860

Distribution: Afrotropical savannas.
Hosts: Nothing known.
Comments: A genus of species with uniform vestiture. Usually found among grasses.

Eurycarenus sessilis Bezzi, 1921
Distribution: Botswana, Lesotho, Mozambique, Namibia, South Africa (KZN).
Mkhuze: *T. sericea* low open woodland.
Phenology: March.
Method: Transect.

Systoechus Loew, 1855

Distribution: Holarctic, Afrotropical, Oriental.
Biology: Many species reared as predators in egg-pods of Acrididae. Can cause significant mortality. Some species attack non-diapausing egg-pods laid at the start of, or during the wet season, others attack diapausing egg-pods laid at the end of the wet season, and a few species attack both. Males hover over a marker to attract females. Species tend to have relatively restricted distributions.

Systoechus bombycinus Hesse, 1938
Distribution: Eastern and northern South Africa, Mozambique, Zimbabwe.
Biology: Not reared. A common species.
Habitat: Savanna.
Mkhuze: *T. sericea* low open woodland, *A. nigrescens* low open woodland, fever tree (*Acacia xanthophloea*) forest, *A. grandicornuta* short open woodland, *C. apiculatum* mountain low thicket.
Phinda: *Acacia nilotica* and *A. karoo* low open woodland, *A. nigrescens* low open woodland.
False Bay: Sand forest.
Phenology: November, January, February.
Method: Pan trap blue, pan trap yellow, transect, baited trap, sweep, general.

Systoechus chrystallinus Bezzi, 1924
Distribution: Kenya, Malawi, Mozambique, South Africa (KZN*), Tanzania, Zambia. Eastern lowlands.
Biology: Not reared.
Habitat: Arid savanna.
Mkhuze: *A. nigrescens* low open woodland, sand forest.
Phenology: January, March.
Method: Transect.

Systoechus sylvaticus Hesse, 1938
Distribution: Eastern South Africa, Mozambique, Swaziland.
Biology: Not reared. A common species.
Habitat: Savanna.
Mkhuze: *T. sericea* low open woodland, *A. nigrescens* low open woodland, fever tree (*A. xanthophloea*) forest, *C. apiculatum* mountain low thicket, *A. grandicornuta* short open woodland.
Phinda: *A. nigrescens* low open woodland, *Acacia leuderitzii* low thicket, *A. nilotica* and *A. karoo* low open woodland.
False Bay: *Acacia tortilis* woodland.
Phenology: November, January, March.
Method: Pan trap yellow, pan trap blue, transect, general.
Comments: A variable species.

Lomatiinae
Lomatiini

Notolomatia Greathead (1998)

Distribution: Afrotropical.
Hosts: Not reared.
Comments: Short fleshy mouthparts. Fly near ground.

Notolomatia heterocoma (Hesse, 1956)
Distribution: South Africa (KZN), Tanzania, Zimbabwe.
Mkhuze: *T. sericea* low open woodland, *A. nigrescens* low open woodland, *Spirostachys* low open woodland, *C. apiculatum* mountain low thicket.
Phenology: November, January, February, March.
Method: Pan trap yellow, sweep, transect.

Anthracinae
Anthracini

Spogostylum Macquart (1840)

Distribution: Afrotropical, southern Palaearctic, Oriental.
Hosts: Most records are as parasitoids of solitary bees and wasps nesting in soil, egg pods of Acrididae and their predators, and pupae of Lepidoptera and their parasitoids in soil.
Comments: Dull sandy coloured species that are inconspicuous when resting on patches of open ground.

Spogostylum incisurale (Macquart, 1840)
Distribution: Southern and eastern Africa as far north as Uganda.
Hosts: Reared in South Africa from pupae of *Loxostege frustalis* Zeller and cocoons of its braconid parasitoid, *Macrocentrus maraisi* (Nixon) (Mohr, 1990).
Habitat: Savanna and steppe.
Mkhuze: *A. grandicornuta* short open woodland, *T. sericea* low open woodland, *A. nigrescens* low open woodland, *C. apiculatum* mountain low thicket.
Phenology: November, March.
Method: Transect, general.

Anthracinae
Exoprosopini

Exoprosopa Macquart, 1840

Distribution: All continents except Antarctica; particularly diverse in Afrotropical Region, but see Comments.
Hosts: Parasitic in cocoons of solitary wasps (Sphecidae, Pompilidae, Tiphiidae—mostly Nearctic records); only 12 records world-wide for approx. 340 species.
Comments: Lambkin *et al.* (2003) have shown that *Exoprosopa* as usually defined is polyphyletic; most afrotropical species will have to be removed to other genera. Short fleshy mouthparts. Rest on ground and vegetation. Strong fliers when disturbed, but do not travel far.

Exoprosopa apiformis (Hesse, 1956)
Distribution: Eastern South Africa.
Hosts: No records.
Habitat: Savanna.
Mkhuze: *A. leuderitzii* low thicket, *A. nigrescens* low open woodland, *T. sericea* low open woodland
Phenology: November.
Method: Transect.

Exoprosopa dimidiata Macquart, 1846
Distribution: West, East and South Africa.
Hosts: No records.
Habitat: Savanna.
Mkhuze: *T. sericea* low open woodland.
Phenology: January, March.
Method: Transect.

Exoprosopa elongata Ricardo, 1901
Distribution: South Africa (Gauteng, KZN*, Northern Cape), Zimbabwe.
Hosts: No records.
Habitat: Savanna.
Mkhuze: *C. apiculatum* mountain low thicket.
Phenology: March.
Method: Transect.
Comments: Only one specimen.

Exoprosopa major Ricardo, 1901
Distribution: Malawi, Mozambique, South Africa (KZN), Tanzania.
Hosts: No records.
Habitat: Lowland east coast savanna.
Mkhuze: *T. sericea* low open woodland.
Phenology: January.
Method: Transect.
Comments: Only one specimen.

Exoprosopa metopargyra Hesse, 1956
Distribution: South Africa (KZN*, Northwest Province).
Hosts: No records.
Habitat: Savanna.
Mkhuze: *C. apiculatum* mountain low thicket.
Phinda: *A. nilotica* and *A. karoo* low open woodland.
Phenology: January, March.
Method: Transect.
Comments: One specimen only from each locality. Previously only known from the two specimens of the type series.

Exoprosopa morosa Loew, 1860
Distribution: Mozambique, South Africa (Eastern Cape, Gauteng, KZN).
Hosts: No records.
Habitat: Wooded savanna.
Mkhuze: *Spirostachys* low closed woodland, *A. leuderitzii* low thicket.
Phenology: November.
Method: Transect.

Exoprosopa punctulata Macquart, 1840
Distribution: Eastern Africa south from Eritrea.
Hosts: No records.
Habitat: Savanna with good grass cover.
Phinda: *A. leuderitzii* low thicket.
Phenology: January.
Method: Transect.
Comments: A common species often found flying amongst grass stems (approx. 1 m).

Heteralonia Rondani, 1863

Distribution: Mainly Afrotropical, also southern Palaearctic and Oriental.
Hosts: Only 3 records—from cocoons of Pompilidae and Tiphiidae; also 'ex dead unparasitized locust'.
Comments: No clear cut differences between the subgenera, based on wing venation; they have been retained for convenience in dividing up a very large genus (approx. 138 spp.).

Heteralonia (*Metapenta*) *corvina* (Loew, 1860)
Distribution: Malawi, Namibia, South Africa (Eastern Cape, Free State, KZN), Zimbabwe.
Hosts: No records.
Habitat: Savanna and steppe.
Mkhuze: *A. leuderitzii* low thicket, *A. grandicornuta* short open woodland.
Phenology: November, January.
Method: Transect, general.

Litorhina Bowden, 1975

Distribution: Mainly Afrotropical and Arabia, also Oriental.
Hosts: Parasitic in mud wasp nests and cocoons of Tiphiidae.
Comments: Very uniform in appearance with a striking disruptive colour pattern. Long proboscis with narrow labella.

Litorhina nyasae (Ricardo, 1901)
Distribution: Botswana, Malawi, Mozambique, South Africa (KZN*, 'Transvaal'), Tanzania, Zimbabwe.
Hosts: No records.
Habitat: Savanna woodland.
Mkhuze: *T. sericea* low open woodland.
Phenology: March.
Method: Transect.
Comments: One record only.

Litorhina obumbrata (Bezzi, 1924)
Distribution: 'Congo', Namibia, South Africa (KZN), Tanzania, Zimbabwe.
Hosts: No records.
Habitat: Savanna woodland.
Mkhuze: *A. nigrescens* low open woodland, *Aloe marlothii/Combretum* woodland.
Phenology: January, February.
Method: Transect, general.

Micomitra Bowden, 1964

Distribution: Afrotropical, Palaearctic, Oriental.
Hosts: One Palaearctic species repeatedly reared as a parasitoid of pupae of Myrmeleontidae.
Comments: Behave like *Exoprosopa* species. Species have patches of white and/or opalescent scales, otherwise dull coloured with hyaline wings.

Micomitra perlucida Hesse, 1956
Distribution: Mozambique, South Africa (KZN).
Hosts: No records.
Habitat: Woodland.
Mkhuze: *T. sericea* low open woodland.
Phenology: January.
Method: Transect.
Comments: One only.

Anthracinae
Villini

Exhyalanthrax Becker, 1916
Distribution: Principally Afrotropical and Palaearctic, also Oriental and Australasian.

Hosts: Parasitoids in puparia of Diptera, also cocoons of Ichneumonoidea and occasionally their hosts. One species reared from cockroach oothecae.

Exhyalanthrax transiens (Bezzi, 1921)
Distribution: Eastern Africa from Kenya south to South Africa (Eastern Cape).
Hosts: Reared as parasitoid in puparia of *Glossina* species in Hluhluwe and Umfolozi reserves before tsetse eradication (Fiedler & Kluge 1954), and also in Kenya (Markham 1986).
Habitat: Savanna, woodland.
Mkhuze: *T. sericea* low open woodland, *A. leuderitzii* low thicket, *A. grandicornuta* short open woodland, *Aloe marlothii/Combretum* woodland, sand forest.
Phinda: *A. nilotica* and *A. tortilis* open woodland, *A. leuderitzii* low thicket.
Phenology: November, January, February.

APPENDIX 2

Bombyliidae recorded from northern coastal KwaZulu-Natal. Asterisk indicates species found in Mkhuze and Phinda reserves. Months are given as Roman numerals.

Bombyliidae collected by W.E. Jones at Mfongosi.
Note. These form the only extensive collection of Bombyliidae from a single area in KwaZulu-Natal. W.E. Jones was the owner of a trading store in the Kranskop region near the Tugela River, well south of the Maputaland centre (B. Stuckenberg, pers. comm.).

Toxophorinae: Gerontini

Geron nomadicus Hesse, 1938 (iii–iv.1935)

Toxophorinae: Toxophorini

Toxophora diploptera Speiser, 1910 (iii, x.1935)
Toxophora punctipennis Bezzi, 1921 (v.1916)

Toxophorinae: Systropodini

Systropus zuluensis Hesse, 1938 (xii.1911)

Bombyliinae: Bombyliini

Bombylella delicata (Wiedemann, 1830) (iii.1911)*
Bombylella elegans (Wiedemann, 1828) (xii.1911)
Bombylella kilimanjarica (Speiser, 1910) (iii.1911)
Bombylella rufiventris (Macquart, 1846) (xii.1911)
Bombylisoma cinereitinctum (Hesse, 1938) (iv–v.1934, xii[sic]–ii.1935)
Eurycarenus laticeps (Loew 1852) (xii.1914)
Systoechus bombycinus Hesse, 1938 (iii.1914, iii.1916)*
Systoechus deceptus Hesse, 1938 (n.d.)
Systoechus inordinatus Hesse, 1938 (v.1917)
Systoechus neglectus Hesse, 1938 (xii.1914)
Systoechus silvaticus Hesse, 1938 (n.d.)*

Mariobezzinae

Hyperusia minor Bezzi, 1921 (iv.1916)

Lomatiinae: Lomatiini

Canariellum acutangula (Loew, 1860) (ii, xii)
Notolomatia chraecoptera (Hesse, 1956) (iii.1916)
Notolomatia pictipennis (Wiedemann, 1828) (xii.1911)
Notolomatia pulchriceps (Loew, 1860) (n.d.)

Anthracinae: Anthracini

Anthrax hemimelas Speiser, 1910 (xii.1911)
Anthrax pitheceus Fabricius, 1805 (x.1911)
Anthrax triatomus Hesse, 1956 (v.1916)
Spogostylum robustale (Hesse, 1956) (iv–v.1934), possible synonym of *S. incisurale*

Anthracinae: Exoprosopini

Atrichochira pediformis (Bezzi, 1921) (iii.1917)
Exoprosopa heros (Wiedemann, 1819) (xii.1911)
Heteralonia (*Homolonia*) *neurospila* (Bezzi, 1921) (ii.1914)

Anthracinae: Villini

Exhyalanthrax abruptus (Loew, 1860) (iii.1914)

Anthracinae: Xeramoebini

Petrorossia angustibasalis Hesse, 1956 (iii.1914, vi.1916, vi–v.1931, xii.1916)
Petrorossia fulvipes (Loew, 1860) (n.d.)

Additional Bombyliidae recorded by Hesse and Greathead (DG) from nearby localities. Hesse often did not give detailed localities, but simply 'Zululand'. Lowland species so designated are included.

Bombyliinae: Bombyliini

Toxophora coeruliventris Karsch, 1887: 'Zululand'
Bombomyia discoidea (Fabricius, 1794): 'Zululand'*
Bombylella kilimandjarica (Speiser, 1910): Hluhluwe G.R. (xi.1967), Charter's Creek (Lake St Lucia, xi.1967) (in BMNH, DG)
Bombylisoma rhodesianum Hesse, 1938: Umfolozi Reserve (xi.1992, DG)
Gonarthrus leucomelas Bowden, 1975: 'Zululand'

Anthracinae: Anthracini

Anthrax aygulus Fabricius, 1805: 'Zululand'

Anthracinae: Exoprosopini

Exoprosopa albata Bezzi, 1924: Manguzi River (nr Maputa, xi–xii.1945), Imyalazi River (xii.1928), Hluhluwe Reserve (i.1950)
Exoprosopa brachipleuralis Hesse, 1956: Pongola River (x.1929), probably a synonym of *E. luteicosta*
Exoprosopa dimidiata Macquart, 1846: 'Zululand'*
Exoprosopa major Ricardo, 1901: 'Zululand'*
Exoprosopa luteicosta Bezzi, 1921: Manguzi River (nr Maputa xi–xii.1945), Shangawana (x.1938)
Exoprosopa morosa Loew, 1860: 'Zululand'*
Heteralonia (*Acrodisca*) *katonae* (Bezzi, 1924): St Lucia Bay (x.1920), Shangawana (x.1938)
Ligyra nigripennis (Loew, 1852): 'Zululand'
Ligyra vittata (Ricardo, 1901): 'Zululand'
L. paris is doubtfully a distinct species
Litorhina nyasae (Ricardo, 1901): Hluhluwe Reserve (iv.1951)*
Litorhina obumbrata (Bezzi, 1924): 'Zululand'*
Micomitra perlucida (Hesse, 1956): Manguzi River (nr Maputa, xi–xii.1945), Hluhluwe Reserve (i.1950)*

Anthracinae: Villini

Exhyalanthrax abruptus (Loew, 1860): Hluhluwe & Umfolozi reserves (Fiedler & Kluge (1954))
Exhyalanthrax flammiger (Walker, 1849): 'Zululand'
Exhyalanthrax lugens (Loew, 1860): Hluhluwe (viii.1947, viii.1948), Umfolozi (viii.1947) Reserves (also Fiedler & Kluge (1954))
Exhyalanthrax transiens (Bezzi, 1921): 'Zululand'*

APPENDIX 3

Bombyliidae collected in Shimba Hills Nature Reserve, Kenya, 1962–82 and species from similar reserves on the Kenya coast that may be expected to be found there. Months are given as Roman numerals. The dry seasons are December–March and June–September. The term 'savanna' is used to indicate drier savannas away from the coast, and 'coast' for the wetter savannas and woodland on the coast. One asterisk indicates species present at Mkhuze Phinda; two asterisks indicate other species common to Maputaland and the Kenya coast. Square brackets indicate species recorded from around Shimba Hills but not in the park, although they most probably do occur there.

Toxophorinae: Gerontini

Geron psammobates Hesse, 1938: (i, v, x, xii) Eastern Africa
Geron nasutus Bezzi, 1924: (v) East & West African savannas

Toxophorinae: Toxophorini

Toxophora coeruliventris Karsch, 1887: (vi) South & East African savannas
Toxophora diploptera Speiser, 1910: (v–vi) South & East African savannas**

Toxophorinae: Systropodini

Systropus leucoproctus Bowden, 1967: Kenya coast

Bombyliinae: Bombyliini

[*Bombomyia discoidea* (Fabricius, 1794): African savannas]*
Bombylella auricoma (Bezzi, 1924): (viii) North-east & East African savannas
Bombylella delicata (Wiedemann, 1830): (v, viii, xii) Eastern & southern Africa*
Bombylella elegans (Wiedemann, 1828): (xii) South & East African savannas**
Bombylella kilimanjarica (Speiser, 1910): (v–vi, viii, x) East African savannas, Angola**
Bombylella plorans (Bezzi): (i) West & East Africa forest
Bombylella rufiventris (Macquart, 1846): (v) East African savannas**
Bombylisoma gemmeum (Bezzi, 1924): (xii) East African coasts
Bombylisoma nucale (Bezzi, 1924): (viii, xii) East & West African savannas
[*Bombylisoma simba* Bowden, 1973: East Kenya savannas]
Eurycarenus dichopticus Bezzi, 1920: (i, v, xii) African savannas
Eurycarenus loewi Hesse, 1938: (v) East African savannas
Eurycarenus melanurus Bezzi, 1924: (i, v–vi) East African coasts
Systoechus flavicapillis Bowden, 1959: (i, x–xi, iv) Kenya, Tanzania
Systoechus niveicomatus Bowden, 1959: (xii) Kenya, Tanzania

Anthracinae: Exoprosopini

Exoprosopa aurivestrix François, 1962: (i, vi, xii) East African savannas
Exoprosopa decastroi Hesse, 1950: (v–vi) East African coasts
Exoprosopa luteicosta Bezzi, 1921: (v–vi, x) Savannas of north-eastern South Africa**
Exoprosopa punctulata Macquart, 1840: (i, vi, viii, xii) Savannas of north-eastern South Africa*
Exoprosopa rubescens Bezzi, 1924: (v, viii) Eastern Africa

Exoprosopa schmidti Karsch, 1888: (v–vi) Kenya & Tanzania coasts
Exoprosopa selenops Greathead, 2001: (v) Kenya coast
Exoprosopa sp. n. near *claripennis* Hesse, 1956: (v, xii) Kenya coast
Exoprosopa thoracica Bezzi, 1924: (i, v–vi) Eastern Africa
Ligyra nigripennis (Loew, 1852): (x) Eastern African savannas**
[*Ligyra paris* (Bezzi, 1923: West & East African savannas]**
Ligyra sisyphus (Fabricius, 1805): (vi) West & East African savannas
[*Litorhina basalis* Ricardo, 1901): East African savannas]
[*Litorhina pseudocollaris* (Bezzi, 1924): Southern tropical Africa woodland]

Anthracinae: Villini

Exhyalanthrax alliopterus (Hesse: 1956): (i, v–vi, viii, xii) Kenya & Tanzania coasts
Exhyalanthrax transiens (Bezzi, 1921): (v, viii) East & South Africa*
Villa galla Greathead, 1967: (vii) West & East African savannas

Anthracinae: Xeramoebini

[*Petrorossia fulvipes* (Loew, 1860): East & South Africa woodland/savanna]**
Petrorossia tropicalis Bezzi, 1921: (i) African savannas